CLAIMS

1. A mouse interface device for interfacing a user's motion with a host computer and providing force feedback to said user, said mouse interface device comprising:

a mouse object contacted and manipulated by a user and moveable in a planar workspace with respect to a ground surface;

a planar linkage including a plurality of members rotatably coupled to each other, said linkage including a first member coupled to said mouse object and a second member coupled to said ground surface;

two electromagnetic actuators providing forces in said planar workspace of said mouse object, said forces caused by interactions between an electric field and a magnetic field, wherein each of said actuators includes a coil portion integrated with one of said members of said linkage and a magnet portion coupled to said ground surface through which said moveable portion moves, and wherein said actuators are controlled from commands output by said host computer;

at least one sensor coupled to said ground surface and separate from said two actuators, said sensor detecting movement of said moveable portion of one of said actuators, wherein said sensor provides a sensor signal including information describing said movement of said moveable portion from which a position of said mouse object in said planar workspace can be determined.

2. A mouse interface device as recited in claim 1 wherein said planar linkage includes four members coupled to a ground member.

3. A mouse interface device as recited in claim 2 wherein said linkage is arranged such that a first base member is rotatably coupled to a ground member, a link member is rotatably coupled to said base member, a second base member is rotatably coupled to said ground member, and an object member is rotatably coupled to said link member and said second base member, wherein said mouse object is coupled to said object member.

4. A mouse interface device as recited in claim 3 wherein said first base member and said second base member pivot about a single axis with respect to ground member.

5. A mouse interface device as recited in claim 3 wherein said first base member and said second base member are rotatably coupled to said ground member, and wherein said link member is rotatably coupled to a mid-portion of said object member.

6. A mouse interface device as recited in claim 5 wherein said moveable portion of one of said actuators is an end of said first base member, wherein one of said wire coils is integrated in said end of said first base member, and wherein said moveable portion of the other one of said actuators is an end of said second base member, wherein the other one of said wire coils is integrated in said end of said second base member.

7. A mouse interface device as recited in claim 4 wherein said magnet portion of one of said actuators is coupled to said magnet portion of said other actuator such that a common flux path between said magnet portions is shared by both magnet portions.

8. A mouse interface device as recited in claim 3 wherein said first and second base members are coupled to a rotation point at a mid point of said base members, where one end of each base member integrates said coil such that said coil is spaced from said rotation point of said member, thereby providing mechanical advantage to forces generated by said actuator on said base members.

9. A mouse interface device as recited in claim 6 wherein said sensors are digital encoders.

10. A mouse interface device as recited in claim 9 wherein said ends of said first base member and said second base member include an encoder arc having a number of equally spaced marks provided, said marks being detected by said encoders when said member moves.

11. A mouse interface device as recited in claim 6 wherein said sensors are lateral effect photo diodes including an emitter and a detector.

12. A mouse interface device as recited in claim 3 wherein said mouse object is rotatably coupled to said object member.

13. A mouse interface device as recited in claim 12 wherein said mouse object rotates about an axis of rotation though said object member, said axis of rotation being perpendicular to said ground surface.

14. A mouse interface device as recited in claim 2 further comprising a stop mechanism for limiting movement of said mouse object in four directions in said planar workspace to a desired area.

15. A mouse interface device as recited in claim 14 wherein said stop mechanism includes a guide opening provided in said ground surface and a guide pin coupled to said linkage, wherein said guide pin engages sides of said guide opening to provide said limits to said movement in said planar workspace.

16. A mouse interface device as recited in claim 2 further comprising a safety switch that causes said actuators to be deactivated when said user is not contacting said mouse object.

17. A mouse interface device as recited in claim 16 wherein said safety switch is a contact switch opened when said user removes weight of his or her fingers from said mouse object.

18. A mouse interface device as recited in claim 2 wherein said interface device and said host computer communicate using a Universal Serial Bus (USB), and wherein power to drive said actuators is retrieved from said USB.

19. A mouse interface device as recited in claim 3 further comprising a local microprocessor, separate from said host computer system and coupled to said host computer system by a communication bus, said microprocessor receiving sensor signals from said sensors and sending output control signals to said actuators to control a level of force output by said actuators.

20. A mouse interface device as recited in claim 3 wherein said mouse object is supported by a support separate from said linkage and provided between said mouse object and said ground surface.

21. A mouse interface device as recited in claim 20 wherein said mouse object is supported by low friction Teflon pad.

22. An interface device for providing force feedback to a user of said interface device, wherein a host computer is coupled to said interface device and implements a graphical environment with which said user interacts, said interface device comprising:

a user object physically contacted and manipulated by a user in two degrees of freedom with respect to a ground surface;

a mechanical support linkage including a plurality of members, said support linkage coupled to said user object and providing said two degrees of freedom, said linkage including two base members coupled to said ground surface;

a plurality of voice coil actuators, each of said actuators including a wire coil integrated with one of said base members of said linkage, wherein said wire coil moves through a magnetic field provided by a plurality of grounded magnets surrounding said wire coil, and wherein a housing providing a flux path surrounds said magnets, each of said wire coils being coupled to an end of a

different member of said support linkage, said coils guided through said magnetic field by said linkage; and

a sensor detecting movement of said members having said wire coils, wherein said sensor includes an emitter that emits a beam of energy and a detector that detects said beam, wherein both said emitter and said detector of said sensor are coupled to said ground surface.

23. An interface device as recited in claim 22, wherein said mechanical support linkage provides said two degrees of freedom substantially in a single plane.

24. An interface device as recited in claim 23 wherein said mechanical support linkage is a closed loop five bar linkage.

25. An interface device as recited in claim 24 wherein both said coils pivot about a single axis of rotation.

26. An interface device as recited in claim 24 wherein said base members pivot about a single axis of rotation.

27. An interface device as recited in claim 25 wherein said magnets are stacked and share a magnetic flux path.

28. An interface device as recited in claim 24 further comprising a support coupled to said user object that supports said user object on said ground surface in addition to said support linkage.

29. An interface device as recited in claim 24 wherein said two grounded actuators are coupled together and are provided as a single unit.

30. An interface device as recited in claim 23 wherein said sensors include a roller frictionally engaged with said members having said wire coils and an encoder wheel for passing between said emitter and said detector.

31. An interface device as recited in claim 23 further comprising an indexing input device allowing said user to change the offset between a position of said user object and a location of a cursor displayed on a display screen by disabling the mapping between said cursor and said user object.

32. A force feedback mouse interface for interfacing with a host computer system implementing a graphical environment, the force feedback mouse interface comprising:

a mouse object resting on a planar grounded surface to be physically contacted by a user and moved in two degrees of freedom in a planar workspace, said workspace having predetermined limits to movement;

a planar closed loop linkage coupling said mouse object to said grounded surface and allowing movement of said mouse object in said two degrees of freedom, said linkage including a plurality of members, each of said members rotatably coupled to two others of said members;

two grounded voice coil actuators, each of said actuators including a wire coil provided on a different member of said linkage, each of said wire coils pivoting about a single axis of rotation, wherein each of said actuators includes a plurality of grounded magnets in a flux path housing surrounding said wire coil, wherein said housing of one of said actuators is positioned above and contacting said housing of said other actuator, and wherein each of said actuators is receptive to a control signal operative to control an output force from said actuator on said member having said wire coil;

at least one grounded sensor, said sensors detecting motion of said mouse object in said two degrees of freedom, said sensor outputting a sensor signal indicative of said motion.

33. A force feedback mouse as recited in claim 32 further comprising a support resting on said grounded surface that supports said mouse object.

34. A force feedback mouse interface as recited in claim 32 wherein said at least one grounded sensor includes two grounded sensors, each of said sensors including an emitter of a beam of electromagnetic energy and a detector that detects said beam, wherein said sensors detect motion of said members having said wire coils, said sensors outputting a sensor signal indicative of said motion.

35. A force feedback mouse interface as recited in claim 34 wherein each of said sensors includes a grounded emitter and a grounded detector.

36. A force feedback mouse interface as recited in claim 32 wherein said at least one grounded sensor includes a planar sensor pad for sensing the location of contact with a pointer coupled to said linkage.

37. A force feedback mouse interface as recited in claim 36 wherein said planar sensor pad senses a magnitude of force provided against said sensor pad in a direction perpendicular to said two degrees of freedom of said mouse object.

38. A force feedback mouse interface as recited in claim 32 wherein said wire coils and said grounded magnets of said actuators are used as said at least one grounded sensor to sense a velocity of said members on which said coils are provided.

39. A force feedback mouse interface as recited in claim 32 wherein said sensor includes an emitter of a beam of electromagnetic energy and a detector that detects said beam, wherein said beam is guided to said detector by a light pipe, said sensor outputting a sensor signal indicative of said motion.

40. A force feedback mouse interface as recited in claim 32 wherein said sensor includes an emitter of a beam of electromagnetic energy and a detector that detects said beam, wherein a flexible light guide guides said beam from said emmitter to said detector.

41. An interface for providing force feedback and interfacing with a host computer system implementing a graphical environment, the interface comprising:

a mouse object resting on a planar grounded surface to be physically contacted by a user and moved in two degrees of freedom in a planar workspace, said workspace having predetermined limits to movement of said mouse object;

a planar closed loop linkage coupling said mouse object to said grounded surface at one location on said grounded surface and allowing movement of said mouse object in said two degrees of freedom, said linkage including a plurality of members rotatably coupled together by bearings, each of said members rotatably coupled to two others of said members;

two grounded actuators, each of said actuators providing a force in said two degrees of freedom;

at least one grounded sensor, said sensors detecting motion of said mouse object in said two degrees of freedom, said sensor outputting a sensor signal indicative of said motion.

42. An interface device as recited in claim 41 wherein said bearings of said linkage include at least one bearing assembly providing a plurality of layers of balls in grooves.

43. An interface device as recited in claim 41 wherein said bearings of said linkage include at least one snap bearing that includes a cylindrical boss coupled to one member which rotates within a cylindrical cavity of another member, said boss held to said cavity by a spring force.

44. An interface device as recited in claim 41 wherein said bearings of said linkage include at least one snap bearing that includes a cylindrical cavity coupled to one member and a bearing assembly coupled to another member, said bearing assembly including a boss held to said cavity by a spring force, said bearing assembly including two bearings rotatable with respect to each other.

45. An interface device as recited in claim 41 wherein said bearings of said linkage include at least one bearing having a V-shaped edge on one member that rotates within a V-shaped groove of another member.

46. An interface device as recited in claim 41 wherein said actuators each includes a wire coil pivoting about a single axis of rotation, wherein each of said actuators includes a plurality of grounded magnets in a flux path housing surrounding said wire coil, wherein each of said actuators is receptive to a control signal operative to control an output force from said actuator on said member having said wire coil.

add 21